

S-E-C-R-E-T

50X1-HUM

1. In the beginning of 1950, an efficiency of 4% in the 8-mm magnetron for a magnetic field of 6,000 gauss was measured. In July 1950, with a magnetic field of 11,000 to 12,000 gauss, an output power of 12 kw for an input power of 100 kw, i.e., 12% efficiency was obtained. It is not known whether this higher efficiency resulted from the increase in the magnetic field or changes in the construction of the magnetron since the tube had left the laboratory in the interim.

2. The efficiency of the 4-mm magnetron has not been measured, but only estimated. For a magnetic field of 8,000-9,000 gauss, it was 1.5%.

3. Only two 8-mm magnetrons out of each series was successful, so that there were six altogether. Only one of the 4-mm magnetrons could be used.

4. The 8-mm magnetron was tested in the test oscillator. They were wanted as pulse transmitters, supposedly, since the radar laboratory showed much interest in these magnetrons which later were delivered to that laboratory. The engineers of the radar division insisted especially on the exact 8-mm wave length. The 4-mm magnetron was not tested in a test oscillator since it was accidentally broken.

Magnetron Testing Instruments Used at NII-380, Leningrad

A. Test Laboratory

Scientific Research Institute 380 (NII-380), Leningrad, had a magnetron test laboratory where the instruments needed for testing the magnetrons were situated and where the actual testing took place.

B. Equipment of the Magnetron Test Workshops

The most important machinery in the shop consisted of two vertical milling machines made by Till at Zuhl. There were also four lathes in very good condition, used mainly to produce anodes for the magnetron. The anodes were first processed on the lathes and then the slots were stamped out on the vertical milling machine. At first, regular steel was used to stamp out the slots, but later they were cut by saws, to give a better surface. The accuracy of the machine was 1/200 mm. A measuring microscope was used to check the completed anodes.

Some attempts were made to polish the slot surfaces electrolytically, but the Russian engineers were not interested and the tests were forgotten although the samples showed a fine, smooth surface.

The vacuum was measured electrically with a Russian instrument controllable with a Mac plumb to 10^{-6} mm. This instrument would at times indicate 10^{-7} mm while evacuation was going on. The instrument was in constant use and very satisfactory.

C. General Data

One may say that in 1950 the development of magnetrons was carried somewhat beyond the work done in 1948 in Arnstadt. It is probable, however, that the millimeter technique has progressed farther in Britain and America. The advantage in Russia is that a number of young people are being given the opportunity to work on magnetrons. Even students at the Technische Hochschule (Institute of Technology) currently are sent to the institute to work for a few months before final examination. These students on the whole are well prepared theoretically, but are as helpless as children in the laboratory. They could not carry out the simplest measurements when they first came, but after the practical part of the laboratory training was over, they could at least use the various instruments there. The magnetron laboratory is therefore more important educationally than for development purposes.

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D. Instruments Used in the Magnetron Test Laboratory

1. Pulse Generator
2. Electromagnetic Rack for Magnetron Operation
3. Equipment for Making the Pulse Visible
4. Wave Meter
5. Broad Band Amplifier
6. Power Measuring Instrument
7. Mirror Galvanometer
8. Field Strength Meter.

1. Pulse generator: Built to furnish voltages up to 20,000 v and pulse current up to 30 amp, the pulse duration being one microsecond. The pulse frequency may extend to 1,000 cycles. The pulse generator consists of (a) a pulse generator and (b) a pulse amplifier.

a. The pulse generator is an instrument of German make, known during the war as Schnecke (snail). The pulse, of optional polarity, has a maximum output voltage of 150 v and a resistance of 1,000 ohms. Pulse frequency, pulse phase, pulse width (0.5-10 microseconds) and output voltage can be adjusted and measured. The pulse generator supplies the input of the pulse amplifier.

b. The pulse amplifier is designed to amplify the pulse coming from the pulse generator to the values mentioned above. It consists of:

- (1) Preamplifier with power supply unit
- (2) Output stage
- (3) High-voltage instrument

(1) The preamplifier: An LV3 is used in the input stage and a 5D21 in the second stage. The negative impulse, going through the input transformer, reaches the grid of the LV3 as a positive pulse. Amplified, it is taken off as a positive pulse from the load resistance of the LV3 which is situated in the cathode, and is fed to the control grid of the 5D21. At the same time, the 5D21 obtains the necessary negative biasing voltage of approximately 350 v from the load resistance of the LV3. The amplified negative pulse coming from the 5D21 is fed through a pulse transformer to the control grid of the output tube. The primary side of the transformer is damped by a diode IG10 in order to suppress oscillations.

The current supply of the preamplifier comes from two separate rectifiers. One of these furnishes the plate voltage of 1,000 v and screen grid voltage of 400 v for the LV3 and the grid bias voltage of -300 v and screen grid voltage for the 5D21. The second rectifier furnishes the plate voltage of 4,000 v for the 5D21.

(2) Output stage: Positive impulses can be fed to the grids of the output 6C21 tubes by way of the input transformer of the preamplifier. A special rectifier furnishes the grid voltage of 1,500 v for the output tubes. A cutin relay in the direct-current circuit of this rectifier controls the

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primary side of the high-voltage transformer (see below) for the plate voltage. The result is that the plate voltage for the output tubes can be turned on or off if the output tubes have negative bias voltage.

The load resistance of 5 kilohms is in the anode circuit of the two parallel-connected 6C21's. The negative pulse developed across the load resistance is fed into the output of the generator through a capacitor. A damping diode 705A is situated in this output as well as a 1:100 potential divider for taking off the deflecting voltage used to measure the pulse voltage in the visual apparatus.

(3) The high-voltage instrument: The plate voltage for the two output tubes is taken from a special high-voltage rectifier. With the help of a control transformer, the high voltage is variable between 0 and 20,000 v. The current then amounts to as much as 40 ma. The voltage is read on a voltmeter in the high-voltage instrument. The rectifier is cut off by the pulse amplifier, which also contains the transformer controlling the plate voltage for the 6C21.

The whole instrument is connected with a switch and a push button. All the tubes are first heated, whereupon the push button applies the plate voltage.

The button activates a relay connecting the primary sides of all the plate-voltage transformers. A glow lamp connected in series with a relay serves to disconnect the plate voltage if the grid voltage drops to below 200 v.

2. The electromagnetic rack contains an electromagnet to which the magnetron can be connected for testing, and a filament transformer to heat the cathode of the magnetron. A rectifier provides voltage for the magnet. The current in the magnetic coils is adjusted by a control transformer. The maximum induction for a distance of 15 mm between poles is approximately 9,600 gauss. A curve was drawn for all the generally used intervals and the magnetic field intensities can be read at a glance. The voltage of the filament transformer can be adjusted with a control transformer to the voltage necessary for the magnetron. The two windings of the filament transformer are insulated by high-tension insulation. The volt-meter for the filament voltage is also insulated.

The pulse current from the output of the pulse amplifier is fed into the cathode of the magnetron and passes through the anode, the electromagnet and a 10-ohm resistor to ground.

3. Equipment for making the pulse visible: This unit serves to measure the pulse current to the magnetron and the pulse voltage. At the same time it controls the shape of the pulse. The instrument making the pulse visible has two Braun tubes type HR 1/100/1.5 and the necessary power-supply transformer with a rectifier to produce the plate voltage of 1,500 v. The Braun tube which measures the pulse current and the pulse voltage obtains the deflecting voltage for the measuring and deflection plates from the magnetic rack and the pulse amplifier. The measuring plates of the second Braun tube controlling the shape of the pulse have only the deflection voltage from the magnetic rack. The deflecting plates obtain their deflecting voltage from the relaxation oscillator of the pulse generator, which also furnishes the voltage for the return-trace elimination to the Wehnelt cylinder (control or modulating electrode) of the Braun tube.

4. Wave meter. The wave length is measured by determining the distance between two minima which are created in space if waves strike vertically on a metal plate and are reflected therefrom.

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The wave meter consists of a metal disk which can be moved axially with a micrometer screw. The latter has no backlash, so that the movement of the metal disk can be read to 1/100 mm accuracy. In front of the metal disk, at a distance of approximately 2 to 10 wave lengths, there was originally placed a 5 ma thermocouple. Measurements with the thermocouple could be made only at distances of one to two wave lengths, i.e., in the immediate vicinity of the magnetron, which had to have a pulse output of approximately one kw to produce a deflection on the galvanometer. Because of the inertia of the thermocouple, the micrometer screw gave very inaccurate readings (accuracy approx 5-10%).

Wave length measurements improved only when the thermocouple was replaced by a detector. The pulses received by the latter were sufficiently amplified by a wide-band amplifier to become visible on the Braun tube. At the same time, measurements of ten times the wave length were possible (the disk could not be moved farther). The distance from the magnetron had to be greatly increased and oscillations were discovered in magnetrons which previously had been thought to be completely free of oscillations. This was especially noticeable in the 4-mm magnetron. In a good 8-mm magnetron, the wave length could be determined to 0.01 mm. At the same time, this method could be applied to prove the multiwave property of a magnetron since such a magnetron gave different readings at the beginning and end of the test. The frequency spectrum could not be determined at the time, because there was no spectrum analyzer available. The development of a heterodyne frequency meter was taken under advisement.

5. Wide-band amplifier: In conjunction with the wavemeter it serves to amplify pulses received, so that these can be made visible on a Braun tube. The gain is approximately 130 and the bandwidth, approximately 3 Mc.

6. Power measuring instrument: This instrument is used to determine the output of a magnetron with the aid of comparative measurements. The difference in temperature of water which flows at uniform velocity through a tank which is heated by the rf is determined by 40 series-connected thermocouples. At different water temperatures, these thermocouples give off a slight current which can be measured on a galvanometer.

As the rf energy acts on the water, the galvanometer shows a certain deflection. When the rf energy is cut off, the tank can be heated by a small heating coil which is supplied by a special transformer. The output of the latter can be measured and is adjusted during measurements so that it produces the same deflection on the galvanometer as was produced by the rf energy.

Two types of output meters are in use, both working on the same principle and differing only in construction. The containers of the first meter are conical, with very thin glass walls. The cones are approximately 5-6 times the wave length which is to be measured. The diameter is approximately 16-17 mm. Water is admitted concentrically through a narrow glass tube opening at the tip of the cone. The water flows out, also concentrically, from the base of the cone. The 40 series-connected thermocouples are placed outside the cone in the inflow and outflow tube and are connected to the galvanometer. Mean output values of one to 2 w could be measured with sufficient accuracy. This type of meter is quite independent of frequency. At the time of measurement, the glass cone is inserted into a circular wave guide of 17-18 mm diameter. The wave guide can be tuned so that the rf energy supplied to the flowing water is a maximum.

In the second type, the rf energy is supplied to the water by a special radiator connected to a rectangular wave guide which can be tuned. The water container is a flat trolitulvessel with very thin walls, a little longer and wider than the radiator. The sketch (not attached) shows the construction. Due to the construction of the radiator, this type can be used only for a certain

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wave length. Deviation from the wave length best suited for the radiator must not exceed 5-7%. The radiator currently used is designed for an 8-mm wave. Due to faulty construction in the shop, the maximum power was radiated at 8.2 mm.

7. The galvanometer (Multiplexgalvanometer) is turned out by the Dr Lange plant. Its sensitivity is approximately 2×10^{-8} amp per scale division. There are three of these instruments on hand.

8. The field strength meter is made by AEG and consists of a synchronous motor, a rotating coil, and a sensitivity measuring instrument. The coil is exchangeable and the instrument was calibrated in Orsted to fit the coil used at the time.

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